

XXXIII. *An Examination of various Ores in the Museum* &c.
of Dr. William Hunter. By George Fordyce, M. D.
F. R. S. and Mr. Stanesby Alchorne.

Read May 20, 1779.

MINERS and assay-masters being generally employed in finding out metals for profit, without inquiring into the state or combination they are in, have made use of processes adapted, in many cases, to investigate the quantity of metal, guessing often at its state or combination; and specimens being procured from them for cabinets, an erroneous account has not only been given of their contents, but these errors have also crept into books of natural history: for this reason Dr. **FORDYCE** determined to assay many of the doubtful specimens, by processes better adapted to find the state or combination of the metal than those commonly in use; and procured the assistance of his friend Mr. **ALCHORNE**. The result of some of their inquiries they now lay before the Society.

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The first ore we mean to consider is called gold pyrites. Pyrites is an ore of iron, containing sometimes copper, sometimes arsenic, sometimes other metals; generally, if not always, combined with sulphur.

This ore, from its yellow colour, has at first sight been often taken for an ore of gold. It is the most common of all ores, and on examination is very seldom found to contain gold. Specimens, however, have been found from which gold has been procured; and, particularly, there have been found in Fatchobuigna near Zalatna, in Transylvania, masses which contain a large proportion of this metal. Sometimes the gold is in its metallic form, and visible to the naked eye; sometimes it is not: and in these cases the ore has been thought to contain the gold united first with iron, and that compound united with sulphur.

Dr. FORDYCE observes on this proposition, that it has not as yet been proved, that a compound metal can be combined with sulphur. If two metals are soluble in sulphur, and each be separately combined with it, the two compounds may be diffused through one another, as is the case with the compounds of sulphur and iron, and sulphur and copper; which may be diffused through one another: but if we have a compound of two metals, of which one is soluble in sulphur, and the other is not, if

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we apply fulphur to this compound, it will dissolve the one, and leave the other; as, if gold and silver be combined, if we reduce the mass to fine particles, and mix them with fulphur, and throw them into a crucible, heated white hot, and afterwards melt the whole mass, the silver will combine with the fulphur, and the gold will fall to the bottom of the vessel. This being the case, we doubted whether this ore contains the gold in its metallic form, only mechanically mixed with the pyrites; or combined with the fulphur by means of the iron; and therefore subjected a specimen to examination, in which we could not discover, even by the help of a microscope, any particle of native gold.

EXP. I. We powdered one hundred grains of this ore, and boiled it in nitrous acid diluted with water; a solution took place with effervescence. Having digested them together, till the whole soluble part was taken up, and poured off the solution, and made a precipitation by fixed vegetable alkali, the precipitate appeared to be iron. Having washed the remaining part with water, and exposed it in a glass matrass in sand, to nearly a red heat, a very small portion of fulphur sublimed; the remainder was quartzose sand, with particles of gold, which were similar in figure, though small, to the particles of gold found native in veins mixed with various matrixes, and

not at all like particles which had been combined with a *menstruum*, which ought either to have appeared in a powder, whose particles were hardly visible from their smallness; or in crystals similar to one another.

EXP. II. If any metal be combined with sulphur, mercury will not precipitate the sulphur from it; we therefore took 140 grains of the same ore, and triturated it for some hours with about five times its weight of mercury: the powdered ore was washed off from the mercury, the remainder put into glass vessels, and evaporated by heat: a mass of gold was left, but part of it being accidentally lost, its weight could not be ascertained; it did not amount to above two or three grains at most.

The powder, washed off and dried, weighed 134 grains: these, mixed with as much litharge, and four times their weight of fixed vegetable alkali, and one fifth of wheat flower, and the whole melted produced a regulus of lead, weighing 80 grains, which, on cupelling with a few grains of silver, and parting in *aqua fortis*, left one sixteenth of a troy grain of gold.

It is to be remarked, that in great works, where gold is separated from pieces of crucibles, sand, or other matter, by amalgamation, notwithstanding the process be

frequently repeated, and with great care, some small portion of the gold still remains; so that the small quantity left in this case might easily have either escaped the mercury, or, have been left unobserved in the powder combined with small particles of it.

We may therefore conclude, that in this ore the gold was in its native form, and not mineralized.

EXP. III. We examined gold pyrites mixed with quartz, with a deep magnifier, and found evidently native gold interspersed. One hundred grains of this ore, was powdered; and boiled in nitrous acid diluted with water: a solution of iron took place, as in the first experiment. The *residuum* being exposed to a red heat, there was no appearance of sulphur; the gold was found in such large particles, and so similar to native gold, that we did not think it worth while to apply mercury.

The gold being dissolved out by *aqua regia*, a quantity of quartz and arsenical salt was left.

EXP. IV. When gold and silver are found in their metallic form, it is not uncommon to find them mixed; but it seldom occurs, that they are mixed in so large proportion as in an ore obtained from Norway, and which was given to Dr. HUNTER, by Mr. FABRICIUS.

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The ore has the appearance of native silver, in scaly particles, intermixed with a hard quartz, tinged brown in some parts by iron. Twenty-five grains of the mass, where the metal was in the largest proportion, melted with litharge, alkali, and phlogistic matter, and afterwards coppelled, yielded a globule apparently silver weighing two grains which, being boiled in nitrous acid diluted with water, left full nine sixteenths of a grain of fine gold. Hence one hundred pounds of metal obtained from this ore, consists of seventy-two pounds of silver, and twenty-eight pounds of gold.

There is an ore of silver which is commonly called vitreous (*minera argenti vitrea*, or *argentum vitreum*).

This ore has always been supposed to consist of sulphur and silver; because, if we melt sulphur and silver together, they form a mass which resembles it, especially in colour and malleability; but, as we could find no experiment in any author which authorized this conjecture, we determined to endeavour to ascertain it by analysis, Dr. HUNTER not refusing to subject the ore to an assay, although scarce and expensive.

EXP. V. Fifty grains of this ore broken in pieces, for it is too malleable to be powdered, were boiled in nitrous acid diluted with water; the acid dissolved the silver with much difficulty, and left a *residuum*. The solution being
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poured off, and the *residuum* washed and exposed in a glass matrafs to a red heat, there was no sublimate of sulphur, or any thing else obtained. The *residuum*, before it was exposed to heat, did not appear to contain any sulphur; being of a blackish colour after exposure to heat, it had a number of yellow particles mixed, which easily dissolved in *aqua regia*. Tin being applied to the solution made no precipitation, which it would have done if those particles had been gold; hence we supposed they were iron.

The silver was precipitated from the acid by copper: washed and dried it weighed four grains, which, on cop-pelling with lead, lost one twenty-fourth.

There were particles of powdered quartz apparently mixed with the yellow particles left after the solution.

EXP. VI. Being much disappointed in not finding any sulphur in the former experiment, we took three hundred grains of the same ore. We freed it as well as possible from heterogeneous matter: we mixed it with four times its weight of mild fixed vegetable alkali, put them into an earthen body, to which was affixed a glass head, and exposed them to nearly a white heat in a naked fire for a full hour and an half; but no sublimation took place, there distilling only a few drops of water. We then put the body into a melting furnace, and rendered

the whole fluid; as soon as it was melted, it was removed from the fire.

The mass, on concreting, was found divided into two; a black mass a-top, and a metallic mass at bottom. The metal being assayed by solution in nitrous acid and precipitation with volatile alkali, shewed no sign either of gold or copper; lost nothing by coppellation with lead; it weighed 2.13 grains, which were pure silver.

The black mass a-top, or *scoria*, was boiled repeatedly in water, but did not all dissolve. The insoluble part was unfortunately thrown away; but to the solution we added muriatic acid: on the addition of the acid, there was a strong smell of *hepar sulphuris*, and a copious precipitate, which, on being examined by a microscope, appeared to consist of pellucid crystals, without the smallest appearance of sulphur. This precipitation, being exposed to heat, did not smell in the least like sulphur; it was not in the least inflammable. Excepting then the smell of *hepar sulphuris*, there does not appear any mark of sulphur in this ore, and a very small particle of inflammable matter dropping in by accident would give this smell.

The foregoing experiments occasioning some doubt of sulphur's being contained in vitreous silver ore, we endeavoured to investigate it by other means; and after several experiments,

experiments, we made the following one, which seems conclusive.

Half an ounce of silver was precipitated from nitrous acid by copper, in small flaky crystals as usual; being washed and dried, it was mixed with the same weight of sulphur, and put into a crucible, over which another was placed so as to cover it, and the two crucibles were luted together, leaving a small aperture for the escape of vapour, but not so as to admit air for the inflammation of the sulphur. These being put into the fire, as soon as they were heated red-hot, the sulphur in part escaped through the small hole, and as it passed through burnt with a blue flame. The fire was increased to a sufficient degree to melt the mass within; in the mean time the blue flame disappeared, which shewed that no more sulphur escaped.

After we had applied heat enough, as was supposed, to melt the mass, the crucibles were removed from the fire, and being separated when cold, a regular button-like mass was found in the crucible, of a dark lead colour both without and within, brittle, and streaked on the inside, bearing to be cut with a knife, exactly like the vitreous ore, which it in every way resembled. The whole mass gained twenty grains or one twelfth in weight, which may be considered as the true weight of the sul-

phur in this compound, as silver combines with sulphur in its metallic form, without losing its inflammable air. Fifty Troy grains of this compound was powdered with difficulty, from its toughness, and boiled in nitrous acid diluted with water; it dissolved with difficulty, leaving a very small quantity of a light blackish powder, certainly not nearly a grain in weight.

It appears, therefore, that the small portion of sulphur contained in the vitreous ore may have been decomposed by the nitrous acid, and the alkali, or the heat, in the former processes; and we may conclude, that vitreous silver ore is a compound of silver and sulphur, and when pure, that it contains between ninety-two and ninety-three grains of silver in one hundred.

